Small-scale Forestry (2010) 9:153–174
DOI 10.1007/s11842-009-9108-0

RESEARCH PAPER

Woody Plants Diversity and Possession, and Their Future Prospects in Small-Scale Tree and Shrub Growing in Agricultural Landscapes in Central Highlands of Ethiopia

Lalisa Alemayehu Duguma · Herbert Hager

Accepted: 18 December 2009 / Published online: 22 January 2010

Abstract Woody plants diversity and possession in small-scale tree and shrub growing practices among farmers of central highland Ethiopia were assessed by using a complete census of the trees and shrubs existing on farmers' lands. The future prospects of diversity and possession of woody plants in the agricultural landscapes were also investigated by using the farmers' species preferences and seedling demands as indicators. Comparisons were made across wealth classes, proximity clusters to a nearby state forest and land uses. It was found that 27 tree and 21 shrub species exist on lands of the studied households. With increasing wealth status of the households, the tree and shrub species richnesses increased. Tree and shrub species richnesses were highest in boundary plantings and homesteads respectively. Small-scale woodlots had the highest number of tree stems while homesteads contained the highest number of shrub stems. The number of tree stems a household possesses is strongly influenced by distance from the state forest, family size, educational level of the household head and number of iron-roofed houses owned. And, the shrub stems possession is significantly influenced by wealth status, distance from the state forest, land holding size, family size, livestock holding, age of wife and possession of off-farm income sources. The species preference analysis and seedling demand computations indicated that the woody species diversity is less likely to change in the future because there is no difference between the currently existing species and the preferred ones. Nonetheless, the number of tree and shrub stems on the farmers' holdings could increase if the seedling demands of the preferred woody species are met.

L. A. Duguma (✉) · H. Hager
Institute of Forest Ecology, University of Natural Resources and Applied Life Sciences, Peter Jordan Strasse 82, 1190 Vienna, Austria
e-mail: lalisa222@yahoo.com

H. Hager
e-mail: herbert.hager@boku.ac.at

Keywords Tree and shrub · Diversity · Possession · Preference · Proximity · Wealth

Introduction

Deforestation is one of the prominent problems in developing countries. Agricultural expansion, declining farm land productivity, demand for forest products and investments in the forested areas are some of the major underlying factors exacerbating the problem. Ethiopia's forest cover has now dwindled below 3% of the land area from its 40% land cover a century ago (Bishaw 2001). The rate of deforestation is highest in the highland parts of the country mainly due to the human and livestock population increment. Contrary to decline in forest resources, the country's population depends heavily on wood and other non-timber forest products (Bekele 2001; Duguma et al. 2009). This high dependence is because of the poor infrastructural development in the country to provide alternative sources of energy, construction materials and other needed wood products. Altogether, population increment, land shortage, diminishing forest area and high dependence on wood resources facilitate the implementation of small-scale tree and shrub growing (STSG) among the rural community in Ethiopia [which makes up around 85% of the country's population (Feyissa 2006)]. This is also evidenced by a recent study conducted in the northern part of the country using old and contemporary landscape photos, which showed the emergence of eucalyptus woodlands grown for construction wood and fire wood in recent times (Nyssen et al. 2009).

STSG, i.e. growing trees and shrubs by farmers on available land in any pattern for the purpose of providing forest products (construction wood, animal feed, fuelwood, small construction materials) (Shastri et al. 2002; Holden et al. 2003; Kidanu et al. 2004; Rahman et al. 2005) and services (e.g. soil amelioration (Gindaba et al. 2005; Manning et al. 2006; Yadessa et al. 2009), soil erosion control, shade for domestic animals, property demarcation, microclimate amelioration for the farm households) receives increasing attention among farmers these days. For them, it is a means of coping with the scarcity of forest products caused by the depletion of forests. Besides utilization for the farm households, STSG also plays a vital role in conserving tree and shrub genetic resources in agricultural landscapes (Boffa et al. 2005; Kindt et al. 2005; Gibbons et al. 2008; Munishi et al. 2008). Moreover, such tree and shrub growing practices are important sources of income for farm households in areas with market access (Holden et al. 2003; Rahman et al. 2005).

Though farmers grow woody plants for subsistence i.e. for supplying their household with various wood products and services, it is at the same time vital to assess which woody plants are grown on the farms (species diversity) at what scale (relative density) and frequency (relative frequency). By such an assessment the role of farmers and the extent of their contribution to the conservation of the plant genetic resources in farming landscapes could be quantified. These days, as forest resources are being depleted at an alarming rate in the tropical regions, agricultural landscapes are playing a crucial role in harboring various woody plants (Boffa et al.

2008). Zomer et al. (2009) showed that agricultural lands have a considerable amount of tree cover. According to the same report, almost half the globe's agricultural lands have a tree cover of 10%. Therefore, it is justifiable to state that agricultural landscapes play a vital role in the conservation of woody plant genetic resources. Diversity indices like species richness, Shannon index and evenness index could therefore be helpful tools to understand and quantify the extent of biodiversity conservation (with special emphasis on woody plants) in agricultural landscapes though the absolute value of such diversity indices to the farmers may be limited as there is little reward for onfarm biodiversity conservation in the developing countries.

Despite of the importance of STSG for the provision of forest products and services and for the conservation of genetic resources of woody species in agricultural landscapes, it has little attention among forestry departments, biodiversity conservation projects and other agricultural programs in Ethiopia. Because of this, it is one of the less studied onfarm management practices with strong potential for the future. So far, little is known about the amount and diversity of trees and shrubs grown by farmers in STSG and factors influencing it. Degrande et al. (2006) also stated that though many studies have indicated the importance of trees for rural households, the attention given to the actual numbers and densities of trees in different land uses is less. The knowledge of the diversity and possession are very important for the future management, conservation and popularization of STSG among farmers in the central highlands of Ethiopia where forest products scarcity is strongly influencing the remnant forest resources (Duguma et al. 2009). To contribute to this knowledge gap, a study was conducted in Menagesha Suba area with the following objectives: (1) to assess the diversity of trees and shrubs existing in agricultural landscapes; (2) to investigate the distribution and possession of trees and shrubs in small-scale woodlots, boundary plantings, homestead plantings and onfarm tree growing and identify household attributes that affect the possession of woody plants; (3) to elicit the future prospects of trees and shrubs diversity and possession on the smallholder farmers lands taking into account the species preferences and the woody species seedling demands of the households studied.

Materials and Methods

Study Area

The current study was conducted in Menagesha Suba area situated between 8°56′–9°00′N, and 38°31′–38°35′E and located in Welmera and Alemgana districts in Oromia regional state, Ethiopia. The area has an average altitude of 2,330 m above sea level receiving a mean annual rainfall of 1,056 mm and has mean minimum and maximum monthly temperatures of 6 and 22°C respectively. This study area surrounds Menagesha Suba state forest.

Cereal farming is the most dominant land use practice and the community is mainly agrarian (Duguma and Hager 2009). As most land is used for cereal growing, the relative proportion of land allocated to trees and shrubs is low. But

since the area lacks any woodland or forest which is freely accessible for the community to cover their needs for forest products (Duguma et al. 2009), trees and shrubs are grown on small parcels of land which are distinguished as small-scale woodlots, boundary plantings, homesteads or trees on farms. Farmers are using these trees and shrubs for construction wood, fuelwood, animal feed and other ecological services. Duguma and Hager (2009) indicated that construction wood, animal feed and minor construction woods are the scarcest forest products among the households located outside the state forest. The same report also indicated that tree planting was the superior measure the farmers chose as a response to the scarcity of forest products.

Menagesha Suba state forest covers about 3,530 ha at the moment. It is one of the few remnant dry afromontane forests of Ethiopia and is also one of the highly protected forests of the country which is restricted by law against free use by the surrounding community. Nevertheless, the state forest area is gradually diminishing due to encroachment for illegal extraction of forest products and due to use right complexities. For example, Duguma et al. (2009) indicated that as high as 584 trees per hectare are cut illegally in the forest area. For the local farming community, fuel wood collection from the state forest for household use is permitted, but products like construction wood and any type of wood for sale are prohibited.

There has been strong tenure insecurity among the community in the study area especially during 1980s because of the expansion plan for the state forest by the then socialist government ruling the country. According to Duguma et al. (2009) many farm households living inside and around the state forest were displaced and translocated to other places. These farmers reinvaded the land they lost after the fall of the socialist government in the early 1990s. Today, the state forest has its own clear boundary (except in some places) and the government has begun issuing land certificates for the surrounding farmers which at least minimizes the tenure insecurity for farmers outside the forest area.

Farm Households' Selection and Classification

The unit of investigation in this study is a household and hence, household heads were taken to represent their respective households. For the purpose of this study, wealth classes were categorized into three major groups (poor [$n = 23$], medium [$n = 27$] and rich [$n = 24$]). The wealth classification was done by the help of local administrative bodies and the local elders by using criteria like land holding, livestock holding and number of houses owned (Table 1). Accordingly, seventy-four farm households (representing 11% of the farm households living within the study area) were selected and clustered according to their proximity to the state forest (insider [$n = 17$], border [$n = 26$] and far outsider [$n = 31$] farmers). Insider farmers are those farm households living within the area designated for the state forest. These farmers do not have any legal title to land within the state forest area. Most insider farmers work as daily laborers in the state forest even though they still are officially registered as farmers. Border farmers are those living in the area from the forest boundary to a distance $\leq$3 km from the forest boundary and far outsider farmers are those living at a distance >3 km from the forest boundary.

Table 1 Some socioeconomic features of the wealth classes in Menagesha Suba area

	Total land holding (ha)	Family size	Number of houses owned	Livestock holding (TLU)
Poor	1.41	5.17	1.33	1.75
Medium	2.28	6.50	1.59	3.04
Rich	3.76	7.24	2.40	6.90

Note: TLU stands for tropical livestock unit equivalent to 250 kg live animal weight

Data Collection

A complete census of all trees and shrubs was conducted on all the farms owned by the selected households. In addition, the land use types in which the woody plants are grown were specified i.e. small-scale woodlot, boundary planting, homestead and onfarm. For all trees and shrubs existing in each land use type, the species of the encountered trees and shrubs were identified, number of stems was counted and the diameter at breast height (dbh [1.3 m height]) of each of them was measured for those with dbh $\geq$ 5 cm. For those with dbh $<$ 5 cm, only the number of individual plants was counted.

After the vegetation data collection, each head of a farm household was asked for the tree and shrub species they want to plant in the future and the number of seedlings they demand[1] for the respective species. This helps to know the trends in woody plants diversity in the agricultural landscape and also gives a hint if there is a possible change in the future. Every head of the farm household was asked to list up to six woody species (trees and shrubs which they would like to plant) for every of the five major uses i.e. house construction, minor construction (e.g. fencing, farm tools, etc.), fuel, livestock feed and soil conservation and amelioration. Then for every use type, the respective listed species were ranked according to the farm households preference based on which scores of 1–6 were assigned (the first ranked species getting a score of 6 and the last one getting a score of 1).

Data Analysis

The woody plants diversity was estimated by using species richness, Shannon diversity index and evenness index. The indices were selected based on their frequent occurrence in plant diversity assessment studies and ease of applicability. Relative species frequency (%) and relative species density (%) were also calculated for every woody species existing on the farmers holdings to know their relative distribution in the agricultural landscape.

Trees and shrubs preference for future planting was analyzed by using the score given to each of the tree and shrub species for the respective use groups they are

[1] This information was attained by using a question "How many seedlings of the tree and shrub species you mentioned do you want to plant taking into account the land area you have?"

listed for. First, the mean score of a species was computed by dividing the sum of the scores for a given species for a given use by the number of farmers who stated their preference scores ($n = 74$) (Eq. 1). Then, the adjusted relative preference score (ARPS [%]) of a species was computed by dividing the mean score of a species for a given use by the sum of the mean scores of all species listed for the same use, which later was converted into percentage by multiplying it by 100 (Eq. 2). For the overall evaluation of the tree and shrub species preference, the aggregate relative preference score (AGRPS [%]) was computed by dividing the summation of all the ARPSs of a species across all uses by the ARPSs of all species for all uses (Eq. 3). If a species is not used for a given use type, it gets an ARPS equal to 0%. The ARPS is a good indicator for the relative preference of different species within the same use group while the AGRPS is very appropriate for knowing the priority species across all use types for the studied households. Moreover, in communities like in the central highlands of Ethiopia where land shortage does not allow the planting of all the listed species among different communities, AGRPS is an appropriate method for identifying the top ranking species which should be given priority for planting on the small pieces of land available, taking into account the growing niches of the species.

$$\mathrm{MSc}_{\mathrm{Spp}(x),\mathrm{Use}(y)} = \frac{\sum \mathrm{scores}_{\mathrm{Spp}(x),\mathrm{Use}(y)}}{n} \tag{1}$$

$$\mathrm{ARPS}_{\mathrm{Spp}(x),\mathrm{Use}(y)} = \frac{\mathrm{MSc}_{\mathrm{Spp}(x),\mathrm{Use}(y)}}{\sum \mathrm{MSc}_{\mathrm{Spp(all)},\mathrm{Use}(y)}} * 100 \tag{2}$$

$$\mathrm{AGRPS}_{\mathrm{Spp}(x)} = \frac{\sum \mathrm{ARPS}_{\mathrm{Spp}(x)}}{\sum \mathrm{ARPS}_{\mathrm{Spp(all)},\mathrm{Use(all)}}} * 100 \tag{3}$$

where $\mathrm{MSc}_{\mathrm{Spp(x),Use(y)}}$ stands for mean score of species x for use type y; n stands for the number of evaluating farmers (equal to 74 in this case); $\mathrm{ARPS}_{\mathrm{Spp(x),Use(y)}}$ stands for the adjusted relative preference score of species x for use type y in % and $\mathrm{AGRPS}_{\mathrm{Spp(x)}}$ stands for the aggregate relative preference score of a species across all use types in percentage.

The existence of statistical differences in diversity indices, number of stems owned, and seedling demands for trees and shrubs was tested by using analysis of variance (ANOVA) for each of the three wealth classes, proximity clusters and the four land uses. A pairwise means comparison was done by using least significant difference (LSD) for those variables showing significant mean differences. All these analysis were done by using SPSS 15.0 for Windows® software (SPSS Inc. 2006).

In order to see the effect of socioeconomic variables on woody plants possession, household attributes like wealth status, proximity class, family size, size of land holding (ha), livestock number, age of the husband and wife, educational level of the household head, number and type of houses owned, off-farm income sources, number and type of houses owned and number of male and female members in the household were recorded. The analysis was conducted separately for tree and shrub possession using the generalized linear model (GLM) of the quasi-Poisson family with log link function in Biodiversity.R software developed by Kindt and Coe

(2005). Additionally, ANOVA (analysis of deviance) was computed using the same software to know the deviances explained by the predictor variables in the regression analysis. Despite their ordinal nature, wealth status and proximity classes were treated as categorical variables during the GLM procedure. The choice of the GLM for the analysis was because of its ability to accommodate different types of predictor variables within the same function. This helped us to include both the continuous and categorical predictor variables mentioned earlier into the same model. The choice of the quasi-Poisson distribution is to take into account the overdispersion of the data and this helps to estimate the dispersion parameter from the data rather than forcing it to be unity as in normal Poisson distribution.

Results

Trees and Shrubs Diversity on Farmers' Lands

A total of 27 tree species belonging to 18 families and 21 shrub species belonging to 16 families were recorded on the lands of the studied households. The list of trees and shrubs possessed by the households with their use types, relative frequencies, relative densities and nitrogen-fixing abilities are given in Table 2. Most of the trees belonged to the Fabaceae family and the shrubs belonged to variety of families. The majority of trees owned by the households are exotics (88%) with *Eucalyptus globulus* and *Eucalyptus camaldulensis* making 69% of them. These two species also make up 88% of the relative density of all the tree species these households owned. *E. globulus* was the most frequent tree species existing in 71% of the studied farms, followed by *Cupressus lusitanica, Croton macrostachyus* and *E. camaldulensis* existing in 65, 57 and 55% of the studied farms respectively. It was observed that tree species which are grown for construction purposes (house construction wood and minor construction wood) had the highest relative density.

Most of the dominant shrub species (*Catha edulis, Rhamnus prinoides, Dovyalis abyssinica, Justicia schimperiana* and *Vernonia amygdalina)* are endemic (Table 2). These five shrub species account for 94% of the relative density of shrub species owned by the studied households. *C. edulis* alone covers more than half the relative density (61%) because it is the most dominant income generating shrub species. *V. amygdalina* is the most frequently encountered shrub species existing in 75% of the farms followed by *C. edulis, J. schimperiana* and *R. prinoides* recorded in 65, 56 and 53% of the farms respectively.

Most of the trees and shrubs grown by the studied households have multiple uses (Table 2). According to the interviewed farm households, 13 of the encountered species are used for construction wood (both house construction and minor construction wood), 24 species for fuel wood, 15 species for soil amelioration, 29 species for soil erosion control, 25 species for live fencing, 6 species as fodder for livestock and 10 species are used as shade trees for domestic animals. Only four species (*E. globulus, E. camaldulensis, C. edulis* and *R. prinoides*) are intentionally grown for income generation among the households investigated.

Table 2 The relative density (%), relative frequency (%), primary and secondary uses and nitrogen-fixing capability of tree and shrub species in holdings of smallholder farmers in Menagesha Suba area

	Relative density (%)	Relative frequency (%)	Primary uses	Secondary uses	N-fixing
Tree species					
Eucalyptus camaldulensis	49.15	12.62	CW, FW, IC	LF, SE	No
Eucalyptus globulus	38.71	16.31	CW, FW, IC	LF, SE	No
Cupressus lusitanica	6.18	15.08	CW, FW	LF, SE	No
*Croton macrostachyus**	1.61	13.23	LF, SF	SE	No
Grevillea robusta	0.93	4.92	CW	FW, SE, LF	No
Acacia deccurens	0.77	5.23	FW, LF	CW, SH	Yes
Acacia melanoxylon	0.61	3.69	FW, LF	SF, SH	Yes
Millettia ferruginea	0.44	3.69	OR, FW	LF, SH	Yes
Juniperus procera	0.33	4.92	CW, FW	LF	No
*Acacia abyssinica**	0.27	3.69	SF, FW	CW, FI, SE, SH, F	Yes
Persea americana	0.25	2.46	FC, SF	FW, LF	No
*Acacia albida**	0.17	2.77	SF, F, FW	FI, SE, SH	Yes
Casimiroa edulis	0.16	2.15	FC, SF	FW	No
Pinus radiata	0.08	1.23	CW, FW	LF	No
Pinus patula	0.07	1.23	CW, FW	LF	No
Olea europaea ssp cuspidata	0.06	1.85	CW, FW	M, SE, LF	No
Cordia africana	0.05	0.62	CW, FW, SF	SE, SH	No
*Ficus sur**	0.03	0.62	SF, F, FC	SH, FW	No
Schinus mole	0.01	0.62	OR, FW, SH	SE, LF	No
Jacaranda mimosifolia	0.01	0.31	OR, FW, SF	LF, SE	No
Afrocarpus falcatus	0.01	0.31	CW, FW, SH	SE, LF	No
Mangifera indica	0.01	0.31	FC, SH, F	SE, FW	No
*Albizia lebbeck**	0.01	0.62	SF, FW, SH	SE	Yes
*Syzygium guineense**	0.01	0.31	FR, FW, FI	SE, CW	No
Shrub species					
Catha edulis	61.35	13.07	IC	SE	No
Rhamnus prinoides	10.81	10.67	IC	SF, SE	No
Dovyalis abyssinica	10.26	9.87	LF	SE, FW	No
Justicia schimperiana	6.44	11.20	LF	SF, SE, FW	No
Vernonia amygdalina	4.87	14.93	F	SF, SE, FW	No
Carissa edulis	2.17	7.20	LF	SE, FW	No
*Ricinus communis**	1.90	6.13	SF	SE	No
Senna didymobotrya	0.56	5.07	LF	SE	No
Entada abyssinica	0.51	2.13	LF	SE	Yes
Coffea arabica	0.39	4.53	IC	SE	No
*Phytolacca dodecandra**	0.23	3.73	LF, M	SE	No
Sesbania sesban	0.20	2.40	SF, F	SE	Yes
Prunus spp.	0.07	0.27	FC	SE	No

Table 2 continued

	Relative density (%)	Relative frequency (%)	Primary uses	Secondary uses	N-fixing
Caesalpinia decapetala	0.06	1.87	LF	SE	-
Rhus volkensii	0.06	1.87	FC, LF		No
Premna schimperi	0.05	2.13	LF, F	M, SE	No
Prunus persica	0.03	1.87	FC, IC		No
Psidium guajava	0.02	0.53	FC	FI, SE	No
Citrus spp.	0.01	0.27	FC		No
Prunus domestica	0.01	0.27	FC, IC		No

CW construction wood, *FW* fuelwood, *F* fodder, *LF* live fencing, *SE* soil erosion control, *SF* soil fertility improvement, *M* medicinal purpose, *FC* fruit (human consumption), *SH* shade for livestock, *OR* ornamental purpose, *FI* farm implements, *IC* income generation by direct selling

Species marked * are usually not intentionally planted by the owner

The mean number of tree species existing per farm was 4.88 (ranging from 1 to 12) while the mean number of shrub species per farm was 6.32 (ranging from 0 to 17). The mean number of tree stems per ha was found to be 98.53 (ranging from 4 to 1612) and the mean number of shrub stems per ha was 191.50 (ranging from 0 to 1604).

Distribution of Trees and Shrubs Across Different Land Uses

There was a highly significant difference among the land uses in the number of tree stems they contain ($P < 0.001$). The largest mean number of tree stems was recorded in the small-scale woodlots (419) followed by boundary plantings (65) and homesteads (11). Farm lands have the lowest number of trees (5). In general, most trees are confined to small-scale woodlots and boundary plantings. Shrubs are only recorded in homesteads and boundary plantings with a respective mean number of stems of 394 and 100 ($P < 0.001$).

The land uses showed a highly significant difference in their tree species richness ($P < 0.001$) with the highest recorded in boundary planting (2.88 species ranging from 0 to 9) followed by the homesteads (1.68 species ranging from 0 to 12). Woodlots are often grown with a single species. But the shrub species richness was highest in homesteads (3.84 species ranging from 0 to 12) followed by boundary plantings (2.49 species ranging from 0 to 8) ($P < 0.001$).

Effect of Distance from the State Forest on Woody Plants Diversity and Possession

Tree species richness, Shannon diversity index and evenness index did not show any significant difference among the proximity clusters, though the three indices had the highest values among the insider farmers. The border farmers had the lowest tree species richness compared to the other two farmer groups (Table 3).

Table 3 The diversity indices of woody species across wealth classes and proximity clusters in Menagesha Suba area

	Trees			Shrubs		
	Species richness	Shannon index	Evenness index	Species richness	Shannon index	Evenness index
Wealth classes						
Poor	3.96	0.70	0.57	5.22	0.81	0.48
Medium	5.15	0.67	0.43	6.89	0.97	0.51
Rich	5.44	0.79	0.45	6.72	0.90	0.51
Average	4.88	0.72	0.48	6.32	0.90	0.50
Proximity clusters						
Insider	5.11	0.85	0.56	6.39	0.92	0.50
Border	4.46	0.70	0.52	6.23	0.97	0.53
Far outsider	5.10	0.66	0.39	6.35	0.83	0.47

Table 4 The distribution of trees and shrubs across proximity and wealth classes in different land uses

	Number of tree stems per household					Number of shrub stems per household		
	Woodlot	Homestead	Boundary planting	Onfarm	Total	Homestead	Boundary planting	Total
By proximity class								
Insider	–	15.3	43.2	0.2	58.7[a]	408.1	6.9[a]	415.1
Border	308.0	9.0	68.5	15.5	401.1[b]	256.2	108.0[ab]	364.2
Far outsider	573.6	9.2	73.3	0.1	659.2[b]	501.5	144.6[b]	646.1
By wealth class								
Poor	–	5.0	45.7	0.2	50.9[a]	157.9[a]	86.7	244.6[a]
Medium	468.9	14.6	81.3	15.0	579.8[b]	350.6[ab]	57.2	407.8[ab]
Rich	427.3	11.3	64.2	0.0	502.8[b]	668. 7[b]	161.3	842.4[b]

Note: Values across a column followed by different superscript letters within the wealth and proximity classes are significantly different at 5%

Distance from the state forest did not affect the shrub species richness and Shannon diversity index though the former recorded highest value among the insider farmers which could be due to some shrubs which grow in the forest area dispersed by frugivores and other animals into the farm lands. But the evenness index was highest for the border farmers compared to the other groups (Table 3).

With increasing distance from the state forest the tree holding of the farm households increased (Table 4). The regression analysis (GLM with quasi-Poisson family and log link function) also revealed that distance from the state forest is one

Table 5 The GLM coefficients (with quasi-Poisson variance and log link function) describing the possession of woody plants using various attributes of the farm household

Variables	Number of tree stems		Number of shrub stems	
	Coefficient	*P*-value	Coefficient	*P*-value
(Intercept)	1.76	<0.05	5.31	<0.001
Wealth class (1—poor, 2—medium, 3—rich)	0.36		0.67	<0.01
Proximity class (1—insider, 2—border, 3—far outsider)	0.66	<0.001	0.27	<0.05
Land holding (ha)	0.09		0.58	<0.001
Family size	0.17	<0.05	0.12	<0.1
Livestock holding	0.05		0.10	<0.05
Age of wife (years)	−0.00		−0.03	<0.001
Educational level of the household head (number of school years)	0.08	<0.1	0.07	<0.05
No. of iron-roofed houses	−0.70	<0.01	0.09	
Possession of off-farm income sources (1—yes, 0—no)	0.35		1.44	<0.001

Note: P-values are shown only for those predictors displaying significances up to 10% probability level. Only variables which displayed significant effect on the possession of either trees or shrubs were shown

Table 6 Analysis of deviance table for the regression results expressed as percentage of the total deviance using Model II regression

Variables	Number of tree stems		Number of shrub stems	
	Coefficient	*P*-value	Coefficient	*P*-value
All variables	48.91	<0.001	82.60	<0.000
Wealth class (1—poor, 2—medium, 3—rich)	9.14	<0.001	13.71	<0.001
Proximity class (1—insider, 2—border, 3–far outsider)	10.55	<0.001	4.0	<0.001
Land holding (ha)	3.63		37.41	<0.001
Livestock holding (TLU)	1.22		6.16	<0.001
Educational level of the household head (number of school years)	4.35	<0.05	3.65	<0.001
Age of husband (years)	4.09	<0.05	0.22	
Age of wife (years)	0.8		9.43	<0.001
No. of iron-roofed houses	12.46	<0.001	0.15	
No. of thatch-roofed houses	0.04		1.87	<0.05
Possession of off-farm income sources (1—yes, 0—no)	0.28		4.72	<0.001

Note: P-values are shown only for those predictors displaying significances up to 10% probability level. Order of variables is in accordance with their entrance into the model during analysis

of the strong determinants of the number of tree stems possessed by households (Tables 5, 6). This variable alone was able to account for about 11% of the variability in tree stems possessed. The tree stems possession in small-scale

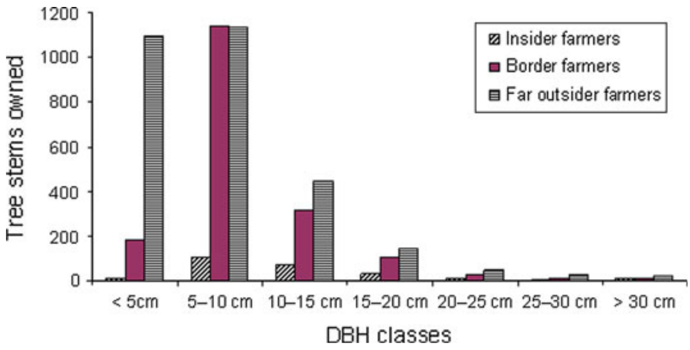

Fig. 1 The distribution of trees possessed across diameter classes (*Note*: computed after adjusting the number of households in each proximity class to 23 households)

woodlots and boundary plantings also increased with increasing distance from the state forest. Distance from the state forest also influenced the shrub stem holdings of the farm households. Nevertheless, it was only able to explain 4% of the variation in shrub holding (presented in Tables 5, 6). Farm households located farther away from the state forest had the highest number of shrub stems and the number of shrub stems in boundary plantings has increased with distance from the state forest (Table 4).

The tree size assessment (based on diameter at breast height) indicated that 73% of the trees inventoried have a dbh less than 10 cm showing the dominance of small trees in the agricultural landscape. As the trees get bigger in dbh the number of trees possessed has decreased (Fig. 1). The possession of big trees (especially dbh $>$ 10 cm) increased with increasing distance from the state forest. Figure 1 also illustrates that most of the young tree saplings are owned by the far outsider farmers which indicates the continuity of tree planting among this farmer groups while the other two groups have very few young trees.

Effect of Household's Wealth Status on Woody Plants Diversity and Possession

Tree species richness has increased with increasing household wealth status but with no significant difference between the groups (Table 3). This lack of difference could be due to the familiarity of the farmers with a limited number of tree species as was confirmed by them. It was also observed that tree species richness per ha has a decreasing trend with wealth status of the owners (3.65, 3.22 and 1.86 species per ha for the poor, medium and rich households respectively). This indicates that the poor households have more diverse tree species per unit land area as compared to the other groups. Household wealth status did not affect the Shannon diversity index and the evenness index of tree species. Boffa et al. (2008) also stated that wealth status did not influence either the onfarm abundance or diversity of tree species around Mabira Forest reserve, Uganda. On the contrary, Jarvis et al. (2000) and Kindt et al. (2004) showed that wealth is an important socioeconomic factor influencing onfarm tree diversity and farmer choices of crop varieties respectively.

Wealth status failed to show a vital effect on the number of tree stems a household owned though it accounted for around 9% of the variability in tree holdings (Tables 5, 6). The poor households have the lowest number of tree stems as compared to the medium and rich ones (Table 4). Adjusting for the size of land holding, the mean number of tree stems owned is highest for the medium households (166 stems per ha).

In comparison, shrub species richness increased with increasing wealth status (Table 3) while per unit land area an opposite trend shows a declining shrub species richness with increasing wealth status (5.40, 4.63 and 2.44 species per ha for poor, medium and rich households respectively). The two other diversity indices for shrub species were not affected by the difference in wealth status.

The number of shrub stems owned increased with increasing wealth status (Table 4). The GLM regression analysis showed that wealth status is a strong determinant of household shrub stems possession explaining around 14% of the variability. Per unit area of land owned, the poor households have the highest number of shrub stems on their farms (238 stems per ha) relative to the two other groups.

Effect of Various Household Attributes on the Possession of Woody Plants

The results of the regression analysis (GLM with quasi-Poisson family and log link function) indicated that number of tree stems possessed per household is significantly influenced by distance from the state forest, educational level of the household head, number of iron-roofed houses owned and family size (Table 5). These effects were also supported by the analysis of deviance (ANOVA) (Table 6) which also showed that major differences in number of tree stems owned were associated with the first three determinants mentioned above.

The effects of wealth status and distance from the state forest on tree and shrub holdings have been discussed in previous sections. Family size is an important household attribute displaying a significant effect on the number of tree stems possessed. This is associated with increasing demand for timber and other wood products with increasing family size and also the availability of labor within the household that facilitates the growing of trees. Holden et al. (2003) also reported that family size had a substantial influence on tree planting in less-favored areas of the Ethiopian highlands.

The significant effect of educational level of the household head on the tree stems possessed indicates that education plays a vital role in promoting tree growing by farmers as they get a wider and in-depth understanding and knowledge about the role of woody plants both economically, ecologically and socially. Such positive effects of education on tree planting were also reported by Hansen et al. (2005) in Malawi and Nduwamungu et al. (2004) in Tanzania.

The effect of the number of iron-roofed houses owned on number of tree stems possessed is due to the harvesting of the existing tree stems either for renewing or constructing the houses. As the number of iron-roofed houses owned increases, the amount of wood used for construction increases. This need for timber is partly fulfilled by cutting trees planted. Because stumps and very juvenile sprouting

coppices were not considered in this study, households who have cut and used their trees for house construction are expected to have low number of tree stems. This has substantially decreased the number of standing trees possessed by farmers having more iron-roofed houses at the time of the study.

As revealed by the regression analysis, the possession of shrub stems was significantly influenced by wealth status, distance from the state forest, size of land holding, family size, livestock holding, age of wife, educational level of the household head and off-farm income sources (Table 5). This result is also supported by the analysis of deviance test (Table 6). Size of land holding is a strong determinant for the number of shrub stems possessed accounting for around 37% of the variance. It is factual that households with small farm size allocate proportionally more of their land (if not all) for growing crops for household consumption. Hence, the more land a household owns, the higher is the chance to grow shrubs.

The significant effect of livestock holding size on shrub stems possession may be associated with the various uses of the shrubs for the livestock. Shrubs are used as shade for livestock during the day time especially in the dry season. They are also important fencing materials—both as dry fencing wood and live fencing—for the protection of the livestock against attack from wild animals. Some shrubs are also used as feed for livestock. Thus, such contributions of shrubs might have substantially contributed for the positive impact of livestock holding size on the shrub stems possession.

The effect of age of the wife on shrub stems holding may be connected with the local living conditions of the community in the Menagesha Suba area. As indicated in previous sections, most of the shrubs are grown in the homesteads and usually women are responsible for most of the activities going on around residence areas in this study area. This may be explained in the following way: when the wife gets old, her managerial and physical capability to take care of the shrubs grown in the homestead decreases, thereby affecting the number of shrub stems households possess.

Possession of off-farm income source is one of the important variables to create difference in number of shrub stems households owned. On one hand, off-farm income liberates some land area from the necessity to produce food crops and thus increasing the availability of land for shrub growing. On the other hand, it also subsidizes the inputs to the growing and management of the shrubs. Such income sources assist the farmers to buy seedling and chemical inputs like herbicides and to pay other people who work on the farms. The mean number of shrub stems possessed by farmers with and without off-farm income sources were 734 and 482 stems respectively.

Major Constraints for Planting Woody Species

Various constraints have been identified that could affect the growing of woody plants in farmers' holdings. The nature of the constraints depends on the land uses in which the woody plants are to be grown. For example, land scarcity and shortage of seedlings were the predominant constraints for the establishment of small-scale

woodlots. For boundary planting the major problem cited is the shortage of tree and shrub seedlings. And, in homesteads, the absence and shortage of appropriate tree species that can be complementarily grown in such niches is a major constraint. In general, in most of the niches, seedling shortage has been identified as the predominant constraint. The nearby state forest has been the major source of tree seedlings observed in the holdings of the farmers. For example, 15 tree species (63% of the tree species observed on farmers' lands) matched with those species in the state forest. Formerly, a limited amount of tree seedlings have been donated freely to surrounding farmers by the state forest management. But recently, this service has stopped because the state forest workers have observed that some farmers were not caring much for such seedlings donated freely. At the moment only farmers who afford to buy seedlings or are able to get the seedlings from other sources (e.g. from relatives and seedlings from forests) are able to plant new trees.

Future Prospects of Woody Plants Diversity and Possession Using the Species Preference and Seedling Demand as Indicators

The AGRPS has shown that *V. amygdalina*, which scored the highest ARPSs for animal feed and soil amendment, is the most preferred woody species among the studied households in Menagesha Suba area (Table 7). *E. globulus* and *E. camaldulensis* were the next two tree species with the highest AGRPS values, as they are very important species for construction wood and fuelwood—the top ranking priorities of the community in the study area according to Duguma and Hager (2009). Following the above three woody species, *J. procera* (an excellent and durable construction wood species), *D. abyssinica* (one of the ideal species for

Table 7 The ARPS (%) and AGRPS (%) values for the different trees and shrubs in Menagesha Suba area

Tree/shrub species	Adjusted relative preference scores (ARPS) (%)					Aggregate relative preference score (AGRPS) (%)
	House construction wood	Minor construction wood	Soil amendment*	Fuelwood	Animal feed	
V. amygdalina	0.00	10.04	32.80	8.75	72.46	24.81
E. globulus	35.11	17.12	23.08	36.02	0.00	22.27
E. camaldulensis	30.79	14.06	20.37	26.58	0.00	18.36
J. procera	29.99	9.43	0.00	7.13	0.00	9.31
D. abyssinica	0.00	19.56	2.91	2.53	0.00	5.00
J. schimperiana	0.00	6.29	2.38	3.34	12.42	4.89
S. theifolia	0.00	13.54	0.00	0.69	0.00	2.85
C. lusitanica	2.31	1.66	1.32	4.72	0.00	2.00
C. macrostachyus	0.00	0.00	8.47	0.58	0.00	1.81
S. sesban	0.00	0.00	2.38	0.00	4.74	1.42

* Includes both soil amelioration and soil erosion control effects of the plants

live fencing) and *J. schimperiana* (second ranking species for livestock feed) are the next three woody species with high AGRPS values.

All the highly demanded woody species (Fig. 2) are the ones most frequently found in the farmers' lands in Menagesha Suba area. Only *J. procera*, which only exists dominantly in the state forest and rarely on the farms, is an exception. Moreover, these species, with highest seedling demands, are also the ones with highest AGRPS values. The seedling demands per household for the top five woody species i.e. *E. globulus, D. abyssinica, E. camaldulensis, J. procera* and *V. amygdalina* are 1343, 626, 568, 392 and 154 respectively. These are average numbers of woody species seedlings farmers are planning to plant within the time range of 1–3 years if seedlings availability is not limited. The seedling demand for *E. globulus* and *J. procera* increased with increasing distance from the state forest. This could be partly explained by the need to guarantee the wood supply for the farm households located at the farthest distances as it is difficult for them to satisfy these assortments from other sources.

The seedling demands of the farm households were strongly and positively correlated with the size of land holding ($r = 0.44$; $P < 0.001$), livestock holding ($r = 0.34$; $P = 0.004$) and education of the household head ($r = 0.26$; $P = 0.03$). Hence, farm households who have more land and more livestock need to plant more trees and shrubs and the higher the educational level of the household head the better is the motive to grow woody plants.

The seedling demands of the households' was also influenced by their wealth status ($r = 0.27$; $P = 0.025$). The average seedling demands of the poor, medium and rich households were 520, 1636 and 1805 respectively. This could be due to the indirect effect of increasing land holding size with the increasing wealth status of the households.

The AGRPS and the computation of seedling demand indicated that the woody species diversity in the study area is less likely to change in the future because there is no difference between the currently stocking species and the preferred and demanded ones. The species preferences of the household heads were only limited to the woody species they know and are familiar to. And, farmers may be reluctant to plant trees and shrubs they do not prefer unless a strong extension programme is

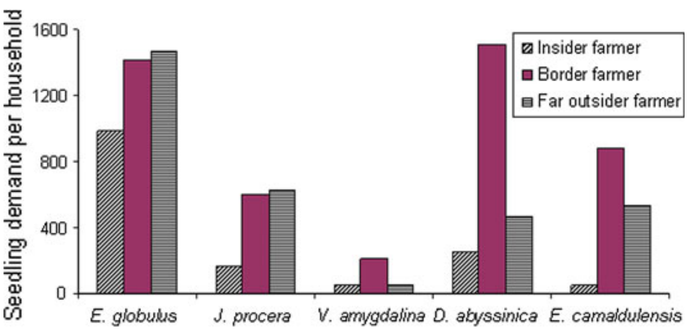

Fig. 2 The seedling demands of the top five woody species by proximity clusters of the farm households

undertaken to advance their knowledge in diverse tree and shrub species suitable for their area. All household heads expressed their interest to know about fast growing tree and shrub species that could be availed for planting in their holdings. Though the limitation in the knowledge about various woody species hinders the change in diversity, at least the number of tree and shrub stems on farmers' holdings may increase to some extent if the seedling demands of the preferred woody species could be met in the near future.

Discussion

Despite the existing farm land constraint, which imposes limits on tree and shrub growing, lands owned by farmers in Menagesha Suba area exhibit remarkable woody species diversity. Nevertheless, compared to other parts of the country (Abebe 2005; Tolera et al. 2008), the diversity is relatively low. Two major reasons that may explain this low diversity could be: (1) the "shadowing effect" of the nearby state forest which was relatively easily accessible for the community in former times (gradually increasing the dependency of the community on the state forest, rather than leading to the establishment of their own sources for forest products) and; (2) the shortage of farm land and woody species seedlings which constrain the establishment of diverse trees and shrubs in rural landscapes.

It was observed that the diversity of trees and shrubs was significantly affected by the land use in which they are grown. Degrande et al. (2006) also reported that land use types have a substantial effect on growing fruit trees in Cameroon and Nigeria. Boundary plantings had the highest tree species richness while homesteads had the highest shrub species richness. Trees are often confined to the boundary of farms mainly to avoid the shading effect on the cereals and to minimize the competition for water and nutrients with the annual crops (usually cereals). The two most dominant tree species (*E. globulus* and *E. camaldulensis*) were often mentioned for their competition effects upon annual crops and hence, they are limited to boundary plantings. The number of tree stems owned was highest in small-scale woodlots followed by boundary plantings. This may be because of the aforementioned reasons, where trees are grown in a way not to affect the annual crops grown nearby. Shrubs dominate the homesteads. This is especially because of the dominance of *C. edulis* and *R. prinoides* (the two economically important shrub species). These two shrub species—accounting for around 87% of the shrub cultivation on farms in Menagesha Suba area—are only grown in homesteads thereby elevating the concentration of shrubs in this land use type. Some shrub species which are especially useful as live fences and animal feed (e.g. *V. amygdalina, D. abyssinica, Carissa edulis* and *E. abyssinica)* are entirely grown along farm borders or homestead boundaries.

Exotic tree species and endemic shrub species are the most abundant ones in the study area. The dominance of the exotic trees can be associated with their fast growing habit as there is a high wood products demand among the community which occurred as a result of the forest resources depletion and restriction of the state forest for extracting major forest products like construction wood.

Insider and far outsider farmers have the highest species richness both for trees and shrubs while border farmers have the lowest. The high species richness observed on the insider farmers lands comparable to the far outsiders may be due to the trees that are retained on the plots of land they live on and also some farmers may bring various tree seedlings from the state forest nursery and plant them at their backyards which all together increases the tree species richness. In the case of the far outsider farmers, the high species richness could be due to the fact that various trees and shrubs are grown for various household needs and ecological services (e.g. shade for livestock and soil erosion control). The low woody species richness observed on the holdings of the border farmers may be due to the resettlement that has been carried out in 1980s. This mobility did not allow them to grow trees and shrubs as they were not wholeheartedly settled.

With increasing distance from the state forest, the farmers' tree and shrub holding has increased significantly, which is contrary to the results obtained by Boffa et al. (2008) around Mabira Forest Reserve, Uganda. This may be due to the fact that farmers living in and near the state forest rely on the forest as major source of various forest products, while those living away from such potential sources tend to establish their own forest products sources. Such differences may lead to enhancement of the tree planting activities, which gradually may increase the number of tree and shrub stems.

The number of shrub stems in boundary planting has increased with increasing distance from the forest which may be due to the increasing dependence on live fences farther from the state forest. As reported by Alemayehu (2005) the insider farmers dominantly depend on the wood from the state forest for fencing their living quarters, while the borders and the far outsiders rely on live fences.

Household's wealth status considerably affected the species richness but did not influence the Shannon diversity and evenness indices. Both tree and shrub species richnesses were highest for the richer households. This effect on species richness could be partly because of the seedling and management costs of the trees and shrubs. Such constraints lead the poor households to focus only on locally available species which are very few in number. Kindt et al. (2004) and Boffa et al. (2008) showed that there is a positive relationship between farm size and species richness in Western Kenya and Uganda respectively. This implies that wealthier households with more land can have more tree species on their possession. The number of tree and shrub stems also decreased with declining household wealth status which also agrees with the findings of Asfaw and Årgen (2007) in Sidama, Ethiopia. This may be also due to the aforementioned reasons (i.e. seedling and management costs) and the diminishing size of land holding with declining wealth status. A positive correlation between the number of trees and shrubs grown and the size of land holding was also reported in Philippines by Emtage and Suh (2004). Shively (1999) also indicated that farm size had a vital influence on farmers' tree planting in the Philippines. In a community, like in the Menagesha Suba area where there is a high human population increment, the major portion of land (if not all) is allocated for food crop production to feed the family thereby decreasing the land assigned for growing trees and shrubs.

The preferences of the farmers for various tree and shrub species indicated that *V. amygdalina, E. globulus* and *E. camaldulensis* are very important and most

preferred woody species. *V. amygdalina* is the highly preferred species for animal feed and *E. globulus* and *E. camaldulensis* are the two top ranking species for construction purposes. Thus, the preferences also agree with the findings of Alemayehu (2005) and Duguma and Hager (2009) where animal feed and house construction wood are the scarcest forest products in the study area. It is to solve these problems that farmers prefer to plant these three woody species at the highest rank. The three species are also characterized by their fast growing habit and the later two especially are preferred among the studied households because of their ability for repetitive coppicing which reduces the costs of establishing new trees. *V. amygdalina* is often grown as boundary planting on farm borders or as live fencing to homesteads. There is no practice of growing this species as a woodlot while the later two species are dominantly grown in woodlots and also in boundary plantings among the wealthy households. Poor households were often observed to grow the two species only as boundary plantings.

The results of the tree and shrub species preferences and farmers quotes for future demands for seedling species showed good agreement and consistency, where the most preferred species got also the highest numbers for seedling demands.

The lack of difference between species currently owned and species preferred for planting may be mainly explained by the lack of knowledge about other alternative species. Some farmers have implicitly expressed that they have no knowledge of other tree and shrub species other than the ones mentioned. Though familiarizing farmers to new and promising species should be the mandate of the extension services in the area, presently there is a negligible effort made to address this issue, due to the dominant focus on other aspects of agricultural activities (e.g. crop management, animal breeding, fertilizer distribution, etc.) by the development agents. Our effort to know the constraints to the extension services through personal communication with the district level agricultural officials led us to know that lack of trained manpower to conduct the extension services, financial limitations to cover the associated costs and the poor attention given to the forestry sector are the major problems (Chimdessa G, personal communication). The first two are also known constraints to the extension services in the country as a whole (Belay and Abebaw 2004). Such networks of problems have made farmers to still keep on growing similar species and continue preferring them too.

From our investigation we found that farmers living at intermediate distance from the state forest (i.e. border farmers) have a strong motive to plant trees and shrubs on their lands. Two major reasons for this may be: (1) the need to strengthen their tenure security by growing long-lasting marks like trees, and (2) the need to supply their forest products demand as the access to the state forest for extraction of forest products has become so tight for the surrounding community. As reported by Melaku (2003) and Duguma et al. (2009), there was a serious state forest boundary conflict in which case the state forest management was claiming the land on which the farmers have already settled after 1991. Most of the border farmers were resettled to another place in the 1980s and came back to the current location after 1991. Farmers explained that growing perennial plants like trees and shrubs provides a visible and concrete indication for the duration of the possession of the land by the owner and hence such plants could serve as a defending evidence against

unpredictable claims that may arise for their land in the future. Moreover, the restriction of the state forest for the extraction of most forest products is necessitating the farmers establish their own sources of forest products which at the same time raises their interest to plant more trees and shrubs. On the other hand, insider farmers are relatively reluctant to plant trees and shrubs for their needs, though they also believed that it is an appropriate measure against the prevalent forest products scarcity in the area (Duguma and Hager 2009). The reluctance could also be because of the lack of land ownership title except for their homesteads. Hence, they are not very motivated to grow trees. In addition to this, as they are living inside the state forest area and can get currently most of the forest products on request, they do not have worries about future problems with forest products even if the overall access right to the state forest is declining with time for them too.

Conclusions and Recommendations

The diversity of trees and shrubs in smallholder farmers' lands of Menagesha Suba area is relatively poor compared to other parts of the country with similar agroclimatic features. Nevertheless, in the face of the existing competition for land among the annual crops and perennials, the agricultural landscapes still have a considerable number of woody species grown on them and thus play a vital role in the conservation of the gene pools of trees and shrubs.

The high tree and shrub species richness in the boundary plantings and homesteads respectively implicates that there is a need to advance and promote such practices to enhance the existence and conservation of perennial plants in the agricultural landscapes as such practices are less competitive for the scarce land resource. The small-scale woodlot, which possesses the highest number of tree stems used by the households for various purposes, should also be promoted widely on non-crop growing lands especially among farm households living outside the forest area.

This study has revealed that the woody plants possession is influenced by various household attributes which need to be taken into account in promoting tree and shrub growing among the farming community. The number of tree stems households' possess is strongly influenced by distance from the state forest, family size, educational level of the household head and number of iron-roofed houses owned. And, the shrub stems possession is significantly affected by wealth status, distance from the state forest, land holding size, family size, livestock holding, age of wife, educational level of the household head and possession of off-farm income sources. The increase of woody plant stem possession with increasing distance from the state forest has important policy implications especially with regards to minimizing the impacts of the nearby communities on the few remnant forests. In order to reduce the human impact on such forests, farmers should be encouraged to grow woody plants for their consumption irrespective of their location from the forest. The significant effect of educational level of the household head on the enhancement of tree and shrub stems possession indicates that advancing the educational coverage for the farming community has an important influence on

farmers' woody plants growing activities. Such educational advancements for farm household heads can also be attained through non-formal educational programs like workshops, farmer schools, field visits to demonstration sites, agroforestry extension programs, etc. to increase the awareness about the importance of woody plants on a wider scale.

The remarkable indication of the study on the role of women in shrub stems possession of a household also implies that it is crucially important to give attention to them in woody plants growing by farm households. This challenges the current norm of the society which gives low credit for women especially on onfarm activities in which the men are often given strong value.

The lack of difference among the preferred and currently stocking species in the agricultural landscapes emanates both from the limited knowledge about other tree species and the lack of seedlings of species which are not currently grown by the farmers. Hence, to enhance the tree and shrub diversity and possession in small-scale forestry (agroforestry) in agricultural landscapes, it should be imperative to advance the extension services provided to the farmers especially on their knowledge about fast growing tree and shrub species. Similarly, important attention should also be given to improve the seedling supply for the farmers so as to promote woody plant growing on the available lands.

Acknowledgments We are very grateful for all assistances rendered to us from the community in Menagesha Suba area. We also thank the Austrian Agency for International Cooperation in Education and Research for financially supporting this study and the first author during his stay in Austria. We also appreciate the assistances of Alemayehu Negassa, Ayantu Tadesse and Getachew Negesse during the field work in Ethiopia. We are also very thankful for the valuable inputs and comments provided by the two anonymous reviewers and the editorial team.

References

Abebe T (2005) Diversity in homestead agroforestry systems in Southern Ethiopia. PhD thesis Wageningen University, Wageningen, The Netherlands

Alemayehu L (2005) Assessment of agroforestry interventions to combat the forest products scarcity in smallholder farmers of Ethiopia. MSc Thesis, University of Natural Resources and Applied Life Sciences, Vienna, Austria

Asfaw Z, Årgen GI (2007) Farmers' local knowledge and top soil properties of agroforestry practices in Sidama, Southern Ethiopia. Agrofor Syst 71:35–48

Bekele M (2001) Forestry outlook studies in Africa (FOSA)—Ethiopia. FOSA Working paper no. 26, 39 p

Belay K, Abebaw D (2004) Challenges facing agricultural extension agents: a case study from South-western Ethiopia. Afr Dev Rev 16(1):139–168

Bishaw B (2001) Deforestation and land degradation in the Ethiopian highlands: a strategy for physical recovery. Northeast Afr Stud 8(1):7–26

Boffa JM, Turyomurugyendo L, Barnekow-Lillesø JP, Kindt R (2005) Enhancing farm tree diversity as a means of conserving landscape-based biodiversity: Insights from the Kigezi highlands, Southwestern Uganda. Mt Res Dev 25(3):212–217

Boffa JM, Kindt R, Katumba B, Jourget JG, Turyomurugyendo L (2008) Management of tree diversity in agricultural landscapes around Mabira Forest Reserve, Uganda. Afr J Ecol 46(1):24–32

Degrande A, Schreckenberg K, Mbosso C, Anegbeh P, Okafor V, Kanmegne J (2006) Farmers' fruit tree-growing strategies in the humid forest zone of Cameroon and Nigeria. Agrofor Syst 67:159–175

Duguma LA, Hager H (2009) Forest products scarcity perception and response by tree planting in the rural landscapes: farmers' views in central highlands of Ethiopia. Ecol Bratisl 28(2):158–169

Duguma LA, Hager H, Gruber M (2009) The community-state forest interaction in Menagesha Suba area, Ethiopia: the challenges and possible solutions. For Trees Livelihoods 19:111–128
Emtage N, Suh J (2004) Socio-economic factors affecting smallholder tree planting and management intentions in Leyte province, Philippines. Small Scale For Econ Manag Policy 3(2):257–271
Feyissa R (2006) Farmers' rights in Ethiopia: a case study. The Fridtjof Nansen Institute. FNI report 7/2006, 64 p
Gibbons P, Lindenmayer DB, Fischer J, Manning AD, Weinberg A, Seddon J, Ryan P, Barrett G (2008) The future of scattered trees in agricultural landscapes. Conserv Biol 22(5):1309–1319
Gindaba J, Rozanov A, Negash L (2005) Trees on farms and their contribution to soil fertility in Badessa, eastern Ethiopia. Biol Fertil Soils 42:66–71
Hansen JD, Luckert MK, Minae S, Place F (2005) Tree planting under customary tenure systems in Malawi: impacts of marriage and inheritance patterns. Agric Syst 84:99–118
Holden S, Benin S, Shiferaw B, Pender J (2003) Tree planting for poverty reduction in less-favoured areas of the Ethiopian highlands. Small Scale For Econ Manag Policy 2(1):63–80
Jarvis DI, Myer L, Klemick H, Guarino L, Smale M, Brown AHD, Sadiki M, Sthapit B, Hodgkin T (2000) A training guide for in situ conservation on-farm. Version 1. International Plant Genetic Resources Institute, Rome
Kidanu S, Mamo T, Stroosnijder L (2004) Eucalyptus-wheat interaction on Ethiopian Nitosols. Agric Syst 80:151–170
Kindt R, Coe R (2005) Tree diversity analysis. A manual and software for common statistical methods for ecological and biodiversity studies. World Agroforestry Centre (ICRAF), Nairobi, Kenya, 207 p
Kindt R, Simons AJ, Van Damme P (2004) Do farm characteristics explain differences in tree species diversity among western Kenyan farms? Agrofor Syst 63:63–74
Kindt R, Noordin Q, Njui A, Ruigu S (2005) Biodiversity conservation through agroforestry: managing tree species diversity within a network of community-based, nongovernmental, governmental and research organizations in western Kenya. ICRAF Working Paper no. 2. World Agroforestry Centre, Nairobi
Manning AD, Fischer J, Lindenmayer DB (2006) Scattered trees are keystone structures—implications for conservation. Biol Conserv 132:311–321
Melaku B (2003) Forest property rights, the role of the state, and institutional exigency: the Ethiopian experience. PhD thesis, Uppsala University, Sweden
Munishi PKT, Philipina F, Temu RPC, Pima NE (2008) Tree species composition and local use in agricultural landscapes of west Usambaras Tanzania. Afr J Ecol 46(1):66–73
Nduwamungu J, Kajembe GC, Malimbwi RE, Mbilinyi BP, Luoga EJ (2004) Household tree planting in Kilosa district, Tanzania. Tanzan J For Nat Conserv 75:99–107
Nyssen J, Haile M, Naudts J, Munro N, Poesen J, Moeyersons J, Frankl A, Deckers J, Pankhurst R (2009) Desertification? Northern Ethiopia re-photographed after 140 years. Sci Total Environ 407:2749–2755
Rahman MM, Furukawa Y, Kawata I, Rahman MM, Alam M (2005) Homestead forest resources and their role in household economy: a case study in the villages of Gazipur Sadar Upazila of Central Bangladesh. Small Scale For Econ Manag Policy 4(3):359–376
Shastri CM, Bhat DM, Nagaraj BC, Murali KS, Ravindranath NH (2002) Tree species diversity in a village ecosystem in Uttara Kannada district in Western Ghats, Karnataka. Curr Sci India 82(9):1080–1084
Shively GE (1999) Prices and tree planting on hillside farms in Palawan. World Dev 27(6):937–949
SPSS Inc (2006) Statistical package for social sciences for windows. Release 15.0.0. SPSS Inc., Chicago
Tolera M, Asfaw Z, Lemenih M, Karltun E (2008) Woody species diversity in a changing landscape in the south-central highlands of Ethiopia. Agric Ecosyst Environ 128:52–58
Yadessa A, Itanna F, Olsson M (2009) Scattered trees as modifiers of agricultural landscapes: the role of *Waddessa* (*Cordia Africana* Lam.) trees in Bako area, Oromia, Ethiopia. Afr J Ecol 47:78–83
Zomer RJ, Trabucco A, Coe R, Place F (2009) Trees on farm: analysis of global extent and geographical patterns of agroforestry. ICRAF Working Paper no. 89. World Agroforestry Centre, Nairobi, Kenya